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The Relationship Between Science Literacy and Critical Thinking Skills Among Students at Public Senior High Schools in Bone Regency

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Abstract: This study aims to analyze the relationship between students' science literacy and critical thinking skills regarding buffer solutions. This study employs a quantitative approach using a correlational method analyzed through simple linear regression. The study population consists of all students at State Senior High Schools in Bone Regency, with samples randomly selected from one class at each school. The instruments used include a science literacy test based on PISA indicators and a critical thinking skills assessment based on Ennis's indicators. Data were analyzed using classical assumption tests, followed by Spearman's rank correlation and regression analysis. The results of the data analysis using the Spearman rank test showed a correlation coefficient of 0.882 with a significance value of 0.000 < α = 0.05. Meanwhile, the results of the linear regression test yielded a correlation coefficient of 0.901 with a significance value of 0.000 < α = 0.05. These results indicate that there is a significant relationship between students' science literacy and their critical thinking skills. Science literacy makes a positive contribution to the improvement of critical thinking skills; thus, the higher the students' science literacy, the better their critical thinking skills.

Keywords: Chemistry Learning; Critical Thinking; Scientific Literacy

Introduction

Science education, particularly chemistry, plays a crucial role in equipping students with 21st-century skills, such as science literacy and critical thinking. Various studies indicate that Indonesian students' science literacy and critical thinking skills do not yet meet expectations. Saputra et al. (2019) reported that only about 33% of Indonesian students possess adequate science literacy. Based on the results of the PISA (2022) science literacy test, Indonesia ranked 63rd out of 81 countries. Another study conducted by Saptaningrum et al. (2023) indicates that students' average science literacy skills fall into the moderate category, while regarding critical thinking skills, research conducted by Hasanah et al. (2023) shows that students' critical thinking abilities are largely in the low category. Similar results were shown by Anita & Firmansyah (2022), where the critical thinking skills of 12th-grade students were still in the low category.

Science literacy is closely linked to critical thinking skills (Jati et al., 2025). Both require the ability to analyze information, evaluate arguments, and draw conclusions based on evidence. In this context, cognitive abilities serve as the primary foundation supporting the development of these two skills. Well-developed cognitive abilities support the improvement of science literacy because they enable students to understand abstract concepts and relate them to real-world phenomena (Hardiansyah & Wahdian, 2023).

Science literacy within the PISA (2025) framework is defined as the ability to engage with science-related issues and scientific ideas as a reflective, information-literate citizen. PISA (2025) identifies three core

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competencies in science literacy: explaining scientific phenomena, evaluating and designing scientific investigations, and interpreting data and evidence scientifically. These three indicators are directly related to the indicators of critical thinking skills according to Ennis (2011), such as: providing simple explanations, building basic skills, drawing conclusions, providing further explanations, and organizing strategies and tactics (Ennis, 2011).

Dayelma et al. (2019) found a very strong correlation between students' science literacy and critical thinking skills in the context of chemical bonding. Another finding indicates that there is a positive relationship between the level of science literacy and students' academic achievement in chemistry. Research conducted by Rahardhian (2023) confirms that there is a significant influence between learning motivation, science literacy, and critical thinking skills, indicating that the development of literacy and critical thinking is not a separate process but rather part of an integrative learning system, which is inseparable from the contribution of cognitive abilities.

Most studies still address science literacy and critical thinking separately. Research by Nuraeni et al. (2019), for example, emphasizes the role of self-efficacy in critical thinking without directly linking it to science literacy. Meanwhile, studies such as those conducted by Febriani et al. (2023); Zahroh & Yuliani (2021) focus more on the development of science literacy-based teaching tools, but have not explicitly explored their impact on critical thinking.

This gap highlights the need for research that specifically examines the relationship between science literacy and critical thinking skills. This study aims to bridge the gap between science literacy and critical thinking skills identified in the literature by empirically examining the relationship between science literacy and critical thinking skills. This study is expected to contribute to the development of effective chemistry learning strategies, as well as strengthen students' cognitive abilities, conceptual understanding, and analytical thinking skills.

Method

The research design employed was quantitative. Data analysis was conducted using correlation tests followed by simple linear regression tests aimed at revealing the relationships among variables. This design was chosen because it provides an overview of the relationships among variables based on the data obtained without any specific treatment. Data collection was conducted simultaneously. Through this concurrent research, the study is expected to provide insight into the extent to which science literacy and critical thinking skills are interrelated.

Research Participants

The population in this study consists of students at Madrasah Aliyah in Bone Regency. The sample in this study is a subset of the population selected to represent the overall characteristics of the population. Sampling was conducted using the cluster random sampling technique, which involves selecting samples based on randomly chosen groups (classes). In this study, each public Madrasah Aliyah in Bone Regency was represented by one class selected at random, so that each class had an equal chance of being selected as a research sample. This technique was used because the population is distributed in natural groups (classes), making it more efficient while still providing a good representation of the population (Creswell & Creswell, 2017). This study was conducted in all State Senior High Schools (Madrasah Aliyah Negeri) in Bone Regency, involving 4 schools as research sites. At each school, one class was selected as the research sample, resulting in a total of 114 students in this study. All selected samples were at the same educational level and thus had the same learning materials and curriculum. The sample size used was deemed sufficient for data analysis to identify the relationship between science literacy and critical thinking skills. An adequate sample size is necessary to minimize statistical error and detect effects that actually exist in the population (Buckley, 2024).

Research Instrument

The research instruments used were a science literacy test and a critical thinking skills test, each consisting of five open-ended questions. Each question was designed based on one science literacy indicator and one critical thinking indicator. The science literacy indicators were developed based on the PISA 2025 framework, while the critical thinking indicators were based on Ennis (2011). The level of students' science literacy and critical thinking skills was determined based on the results of the administered tests. Test results were then evaluated using a Likert scale: a score of 2 for correct answers, a score of 1 for partially correct answers, and a score of 0 for incorrect answers. Thus, the maximum score a student could achieve was 10.

Data Analysis

The scores obtained by the students were then used to measure their levels of science literacy and critical thinking. Before the analysis was conducted, grades were first determined based on the scores obtained. The test scores obtained by the students were still raw data, so they needed to be converted to a standardized score

of 100. The score conversion process was performed using the formula proposed (Purwanto, 2007).

$$NP = \frac{R}{SM} \times 100 \quad (1)$$

Explanation:
NP = the value being calculated
R = student's score
SM = maximum test score

The obtained values were then categorized and subjected to further analysis using IBM SPSS Statistics.

Data Description and Categorization

The scores obtained by the students were then converted to percentages and categorized in Table 1. The table contains categories of students' science literacy and critical thinking skills based on the conversion of scores into percentages. The percentage of the scores obtained was then used as the basis for determining the level of achievement of students' science literacy and critical thinking skills. The percentage of scores used was adjusted according to the criteria established (Arikunto, 2013).

Table 1. Categorization of Data on Science Literacy and Critical Thinking Skills

Interval	Category
0–20	Very Low
21–40	Low
41–60	Moderate
61–80	High
81–100	Very High

Classical Assumption Test

The classical assumption tests conducted include the normality test, the homoscedasticity test, the autocorrelation test, and the linearity test. These tests were performed to ensure that the regression model meets the basic assumptions so that the regression model can be considered reliable, valid, and suitable for use in decision-making (Silalahi et al., 2024)

Spearman's Rank Test

The Spearman rank correlation test was used to determine the strength and direction of the relationship between two variables: students' science literacy and critical thinking skills. This test is an alternative to the Pearson correlation test and is used when the data are not normally distributed or are ordinal in nature. The Spearman test analysis was conducted using IBM SPSS Statistics 25 software. The use of the Spearman Rank test in educational research is also supported by various recent empirical studies. Research by Mishra & Pandey (2022) states that the Spearman correlation is a robust method for analyzing relationships between variables when data are ordinal or do not meet the assumptions of a normal distribution, particularly in social and educational research.

Simple Linear Regression Test

The simple linear regression test aims to determine the effect of science literacy on students' critical thinking skills. The simple linear regression model in this study is expressed in the equation 2.

$$Y = a + bX + \gamma \quad (2)$$

Notes:
Y = critical thinking skills
X = science literacy
a = constant
b = regression coefficient
ϵ = error or disturbance variable

Result and Discussion

Central Tendency and Dispersion of Data

Data central tendency describes the overall distribution of science literacy and critical thinking skills scores. Meanwhile, data dispersion describes the variation in science literacy scores. The results of the central tendency and dispersion of students' science literacy and critical thinking skills are shown in Table 2 and Table 3.

Table 2. Central Tendency and Dispersion of Data Science Literacy Skills

Central Tendency and Data Distribution	Science Literacy Test Results
Average	63.1
Median	60.0
Mode	60.0
Highest value	100
Lowest value	20

Table 2. Shows that students' science literacy test scores range from 20 to 100, with an average of 63.1 in the moderate category.

Table 3. Central Tendency and Dispersion of Critical Thinking Skills Data

Data Central Tendency and Dispersion	Critical Thinking Skills Test Results
Average	53.0
Median	50.0
Mode	50.0
Highest value	90
Lowest score	10

Table 3. Indicates that students' critical thinking skills test results fall within the 10–90 range. The average score is 53.0, classified as moderate.

Science literacy and critical thinking skills are two core competencies that are interrelated and inseparable in modern science education. Science literacy has a strong relationship with critical thinking skills because both require the ability to understand, process, and evaluate information logically. categorization of science literacy and critical thinking skills data. The results of the categorization of science literacy data for students at State Senior High Schools throughout Bone Regency are presented in Table 4.

Table 4. Categorization of Data on Science Literacy Skills

Interval	Number of Students	Percentage	Category
0–20	4	3.51	Very Low
21-40	2	1.75	Low
41–60	67	58.77	Medium
61–80	29	25.44	High
81–100	12	10.53	Very High

Table 4 shows that the majority of students have science literacy skills in the moderate category, with a percentage of 58.77. Based on these results, it can be concluded that most students have basic abilities in understanding scientific concepts, applying scientific knowledge, and using scientific information in simple contexts; however, these abilities have not yet developed optimally. This also indicates that students' science literacy skills still require strengthening, particularly in aspects that demand deeper conceptual understanding and analytical skills.

These findings are consistent with the results of a study by Sari & Setiawan (2022), which showed that the majority of students in Indonesia fall into the moderate science literacy category, where students are able to understand basic concepts but still struggle to integrate their knowledge for the analysis and evaluation of scientific problems. Additionally, research by Kurniawan & Nurhayati (2023) also revealed that science literacy skills in the moderate category reflect students' limitations in deep conceptual understanding and analytical skills, particularly in interpreting data and drawing conclusions based on scientific evidence. Meanwhile, the results of the categorization of critical thinking skills data for students at State Madrasah Aliyah across Bone Regency can be seen in Table 5.

Table 5. Categorization of Critical Thinking Skills Data

Interval	Number of Students	Percentage	Category
0–20	6	5.26	Very Low
21-40	28	24.58	Low
41–60	54	47.37	Medium
61–80	24	21.05	High
81–100	2	1.75	Very High

Based on Table 5, it can be seen that the students' critical thinking skills are mostly in the moderate category, accounting for 47.37%. This finding indicates that students have basic abilities to analyze information and draw conclusions; however, their critical thinking skills have not yet developed optimally. The low level of critical thinking skills among students found in this study is also supported by various previous research findings. Zubaidah et al. (2022) reported that students' critical thinking skills at the secondary school level remain in the low category, particularly regarding the interpretation and evaluation of scientific arguments. This situation indicates that systematic efforts are needed through the implementation of learning strategies focused on problem-solving, inquiry, and metacognitive knowledge to enhance students' critical thinking skills. Research by Wulandari & Suyanto (2023) shows that improvements in critical thinking skills can be achieved through the implementation of inquiry-based, problem-solving, and metacognitive-enhancing learning strategies that encourage students to evaluate information more deeply.

Overview of Achievement for Each Science Literacy Competency Indicator

Science literacy achievement scores provide an overview of students' mastery levels across the science literacy competency domains formulated based on the PISA 2025 assessment framework. Science literacy achievement scores are shown in Figure 1.

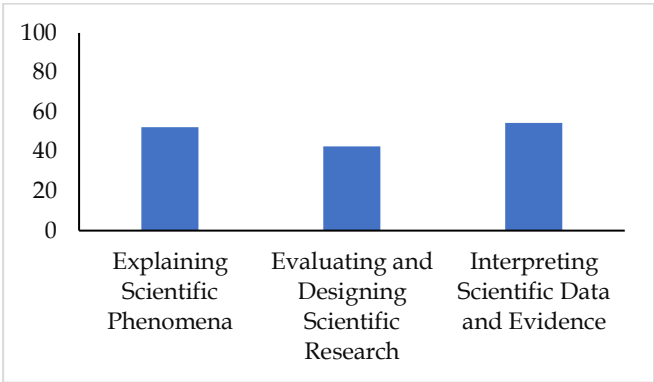

Figure 1. Achievement for Each Science Literacy Competency Indicator

A more detailed analysis of the science literacy indicators shows that students achieved the highest percentage in the aspect of interpreting scientific data and evidence (54.51%), followed by explaining scientific phenomena (51.41%), and lastly, evaluating and designing scientific research (42.54%). This indicates that students are more proficient in basic analytical aspects—interpreting data and evidence—compared to aspects

requiring metacognitive skills and more complex scientific research processes.

This difference in achievement can be explained by the differing cognitive demands of the two indicators. The indicator for interpreting scientific data and evidence emphasizes students' ability to analyze and evaluate information that is already structured in the form of tables, graphs, or experimental results, making it easier to access through practice problems and visual representations frequently provided in science instruction. Conversely, explaining scientific phenomena requires a higher level of conceptual knowledge integration and the ability to explain causal relationships between scientific concepts and real-world phenomena—skills that are often not explicitly practiced in the classroom. This is characteristic of science literacy, where interpreting data often receives high scores because the process is more straightforward, whereas explaining phenomena requires more complex conceptual understanding and advanced thinking skills that demand more intensive inquiry-based learning and reflection. This aligns with previous findings stating that the evaluation and research design aspects often pose challenges for students (Lubis et al., 2025) because higher cognitive levels are required.

Overview of Achievement on Each Critical Thinking Skill Indicator

A comparison of students' critical thinking indicator achievements shows the extent to which students meet the critical thinking indicators proposed (Ennis, 2011). The results of students' critical thinking indicator achievements can be seen in Figure 2.

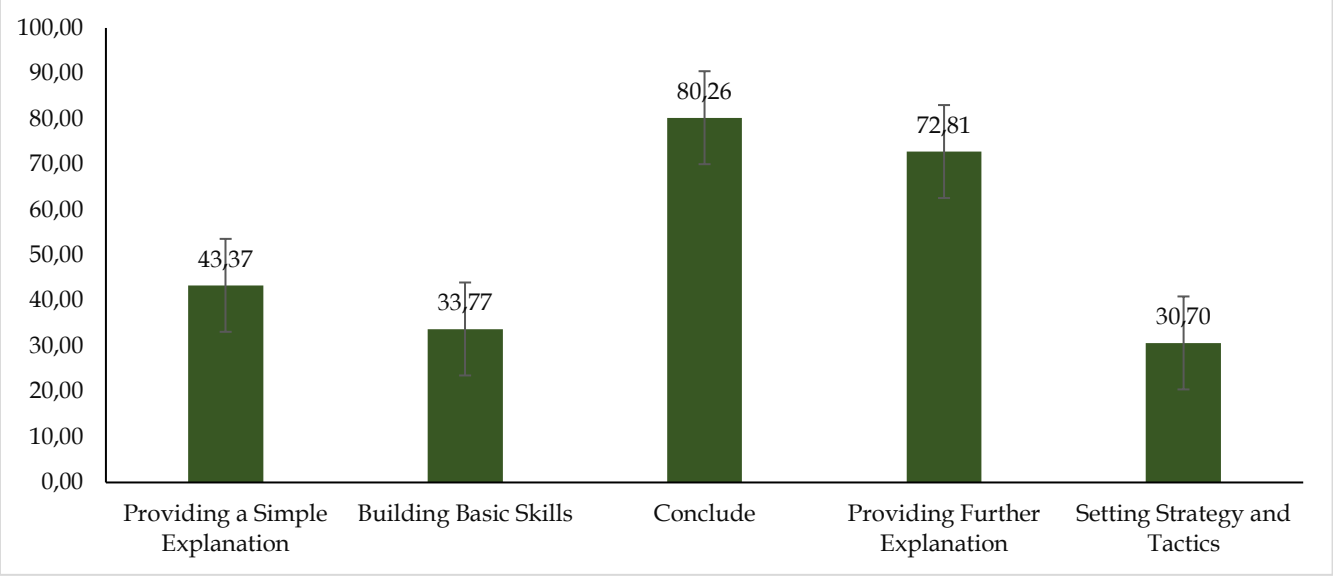

Figure 2. Diagram of Achievement for Each Critical Thinking Skill Indicator

Figure 2 shows that students performed best in the aspects of providing further explanations (72.81) and drawing conclusions (80.26), while the lowest-performing aspects were formulating strategies and tactics (30.70%) and building foundational skills (33.77%). This indicates that students perform better in the aspects of providing further explanations and drawing conclusions because these aspects are related to the ability to reason based on available information or arguments. In the learning process, students are relatively frequently trained to draw conclusions and rephrase information they have acquired, whether through discussions, question-and-answer sessions, or written assessments. Conversely, the aspects of formulating strategies and tactics and developing foundational skills require higher-order thinking skills involving planning, strategic decision-making, and reflection on problem-solving steps. These aspects demand metacognitive awareness and systematic problem-solving-based learning experiences, which generally have not yet developed optimally in students.

The variation in performance across these critical thinking indicators suggests that students' critical thinking skills do not develop uniformly, as each indicator requires a different level of cognitive ability. This finding aligns with Ennis (2011) view, which states that critical thinking consists of a number of sub-skills that develop gradually and are strongly influenced by learning experiences and the instructional strategies implemented by each school.

Testing Classical Assumptions

The results of the tests of the assumptions of the simple linear regression model can be seen in Table 6.

Table 6. Summary of the results of the tests of the assumptions of the simple linear regression model

Classical Assumptions	Test Name	Statistical Value	P-Value/Significance Level	Conclusion
Normality	Sapphiro-Wilk	W=0.9626	0.0028	Not Normal*
Homo-casticity	Breusch-Pagan	BP=0.2380	0.6256	Met
Autocorrelation	Durbin-Watson	DW=1.6452	0.064	Met
Linearity	Ramsey RESET	F=0.3952	0.6745	Met

Based on Table 6, the linear regression model meets most of the classical assumptions, namely homoscedasticity (p=0.6256), absence of autocorrelation (p=0.640), and linearity (p=0.6745). Although the Shapiro-Wilk test showed a p-value < 0.05 for the residuals, the linear regression analysis in this study was still retained. This is supported by Schmidt & Finan (2018), who state that linear regression still provides accurate estimates even if the residuals are not normally distributed. Provided that the sample size is sufficiently large (n > 100), which in this study is 114.

Spearman's Rank Test

The results of the Spearman correlation test between science literacy and critical thinking skills can be seen in Table 7.

Table 7. Results of the Spearman Rank Test

Statistics	Results
Correlation Coefficient	0.882
Sig. (2-tailed)	0.000
Results: Significance level α	0.05
Decision	The data are correlated

Based on the results of the Spearman's rank correlation test presented in Table 7, a significance value (Sig. 2-tailed) of 0.000 was obtained, which is smaller than the significance level of α = 0.05. Thus, it can be concluded that there is a significant relationship between the variables of students' science literacy and critical thinking skills. The correlation coefficient of 0.882 indicates that the level of relationship between the two variables falls into the very strong category. A positive correlation coefficient indicates that the relationship between the two variables is positive, meaning that the higher a student's science literacy ability, the higher their critical thinking skills.

These findings are consistent with the research by Lubis et al. (2025), which, using a bibliometric approach, demonstrated that science literacy and critical thinking are interrelated constructs in modern science education research. Theoretical support for this relationship is also found in the study by Primasari et al. (2020), which indicates a positive correlation between science literacy and critical thinking skills among high school students, albeit on a lower scale (r ≈ 0.618).

Simple Linear Regression Test

Further analysis was conducted using a simple linear regression test to determine the effect of science literacy on students' critical thinking skills ( ). The results of the simple linear regression test examining the relationship between science literacy ( ) and students' critical thinking skills are presented in Figure 3.

Table 8. Simple Linear Regression Test

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	22,728.346	1	22,728.346	484.169	0.000[b]
	Residual	5,257,619	112	46,943		
	Total	27,985.965	113			

a. Dependent Variable: Critical Thinking Skills

b. Predictors: (Constant), Science Literacy Ability

Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-0.527	2.515		-0.210	0.834
	Science Literacy Skills	0.847	0.039	0.901	22.004	0.000

a. Dependent Variable: Critical Thinking Skills

The results of the simple linear regression analysis indicate that science literacy has a significant effect on students' critical thinking skills. A correlation coefficient (R) value of 0.901 indicates a very strong and positive relationship between the two variables. The model's significance, as indicated by an F-value of 484.169 with a p-value of 0.000 (<0.05), confirms that the regression model used is valid and has excellent predictive power. Partially, a regression coefficient of 0.847 with a significance level of 0.000 indicates that a one-unit increase in science literacy ability is associated with a 0.847-unit increase in critical thinking skills.

The magnitude of the contribution of this influence is reflected in the coefficient of determination (R^2) value of 0.812. This means that 81.2% of the variation in critical thinking skills can be explained by scientific literacy abilities, while the remaining 18.8% is influenced by other factors outside the research variables. This high determination value indicates that scientific literacy is a very dominant predictor in explaining variations in students' critical thinking skills. The regression equation obtained, namely Y = -0.527 + 0.847X, shows a positive direction of the relationship, so that an increase in scientific literacy is consistently followed by an increase in critical thinking skills.The theoretical view that science literacy "provides a foundation" for critical thinking is also supported by Tiara & Mubarok (2023), who state that science literacy enables students to engage in the analysis, synthesis, and evaluation of scientific evidence—the core of critical thinking skills. Furthermore, a study by Nugraha et al. (2021) found that science literacy-based learning can enhance critical thinking skills through data interpretation and contextual problem-solving activities. Additionally, the results of a study by Rahman et al. (2024) indicate that students with high levels of science literacy tend to possess better critical thinking skills, particularly in identifying problems, analyzing information, and making decisions based on scientific data.

Conclusion

Based on the research conducted, it can be concluded that there is a relationship between students' science literacy and critical thinking skills, with a correlation coefficient of 0.901. This correlation coefficient indicates a positive relationship and falls into the "very strong" category, suggesting that the higher students' science literacy, the higher their critical thinking skills. This finding underscores the importance of developing science literacy in chemistry education to encourage students to interpret scientific phenomena, solve contextual problems, and develop evidence-based arguments. Thus, critical thinking skills can develop optimally alongside improvements in science literacy.

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